PETROLOGICAL ABSTRACTS AND REVIEWS

BERKEY, CHARLES P. *Geology of the New York City Aqueduct.* N.Y. State Museum, Bull. 146, 1911. Pp. 283, figs. 39, pl. 38.

"Studies in Applied Geology" is the alternative title of this rather unusual work; a caption happier, and far more suggestive than that appearing on the cover of the book, for the value of the data gathered concerning the geology of this region, while great as a matter of record, is still entirely subordinate to the interest accruing from the statement of the methods used by the author in the solution of the numerous problems propounded to him as the consulting geologist of the New York Board of Water Supply. Probably in no previous engineering enterprise has such weight been placed upon the testimony of the geologist, and certainly in few has he been called upon to accumulate facts sufficient to enable him to forecast geological conditions with great accuracy over such a large area.

The author has wisely refrained from making his report a mere catalogue of the facts ascertained. "It is one of the most cherished wishes of the writer of this bulletin that some of the problems may be presented in such a manner as to serve a distinct educational purpose." To this end the problems are developed in the text nearly as they arose in the field—the data are given, with the particular information sought by the engineers; then follows the line of reasoning, and the conclusions reached; and finally the actual state of affairs, as shown by further exploration, is recorded.

The aqueduct, now in course of construction, is designed to carry over half a billion gallons daily, from the Ashokan Reservoir in the Catskill Mountains, to the Hill View Reservoir, just outside of the city, and includes 92.5 miles of aqueduct, with 10 dams; and 18 miles of additional tunnel, with 16 miles more of delivery pipe line in New York City itself.

From the Catskills south to the Highlands the territory under consideration is underlain by Paleozoic sediments, practically complete in section from Lower Cambrian to Upper Devonian, nearly flat and of simple structure to the north, but becoming more complicated in the Hudson River slate region farther down the river. The district lying to the south is underlain by ancient and very complicated crystalline

gneisses, metamorphosed sediments in part, with great masses of igneous intrusions and bosses, and still farther south, in Westchester Co., are gently rolling parallel ridges, formed by a succession of limestone and schist belts. Near the city the underlying Fordham gneiss is frequently exposed. Several igneous masses are also penetrated, and a number of other formations have been barely avoided. The whole area is thickly drift covered, and this feature of course greatly obscures the geology. Recent greater elevation of the continent must also be taken into consideration, since it has resulted in the cutting of inner gorges in most of the valleys (some of which have since been obscured by glaciation), and in the circulation of ground water at depths greater than the present, producing frequent rotten zones and occasional caves below the present ground water level. A wide variety of problems are thus presented, covering the fields of physiographic, glacial, petrographic, and structural geology.

To supplement unusually close field study, the author commanded the resources of an extensive drilling equipment. Wash rigs were used where possible, but the chop and oil-well rigs were usually necessary, and the shot and diamond drills were frequently resorted to. The cores of the latter were preserved, and in many cases subjected to microscopic study; and careful records were always kept of the percentage and condition of the core saved, the rate of progress of the drill, its behavior, the loss of water in the hole, etc. Special pumping tests were made in some of the holes to determine the porosity and perviousness of the rock, this being of course a vital feature in the construction of pressure tunnels.

After a résumé of the geology and physiography of the district, and the principles involved in their interpretation, the author proceeds to a discussion of a number of type problems. Passing briefly over the considerations—chiefly physiographic—which led to the selection of the present aqueduct line, he takes up rather fully the problem of selecting a suitable crossing under the Hudson River. Detailed exploration of a number of points was made, and the Storm King locality finally selected as the most advantageous, chiefly because of the character of the rock, which is a slightly gneissoid granite, in striking contrast to the slate and limestone belts over which the river flows at the other points explored. Drilling at this locality showed bedrock at the extraordinary depth of 751 feet, the assumption being that the gorge was here glacially oversteepened several hundred feet. The geological features involved in selecting the great Ashokan dam site are then considered; they deal chiefly with the character of the bedrock, the assortment and imperviousness of the overlying till, and the general glacial history of this locality.

The crossing of the Rondout Valley has proved one of the most serious difficulties encountered in the whole work, and very detailed study has been given it. This valley is four miles wide and heavily drift covered, and the author was given the problem of deciding on the possibility of driving a pressure tunnel, together with the best place and most favorable depth for such a work. This required the determination of the topography of the buried valley floor; the position, within five feet at any given point, of any one of the twelve irregularly dipping and faulted formations in this valley; the structural and petrologic condition of each, with regard to porosity; and a study of the underground water circulation. While frequent recourse was had, of necessity, to diamond drilling, it was of course very important to determine which sections might safely be left without testing in this expensive and tedious manner. It was decided that the limestones must be avoided, because of their liability to solution by water under such great head, and likewise a heavy but brittle grit, because of the free circulation through it. Under this general type fall most of the other problems, which are concerned largely with the crossing of these old buried valleys. In New York City itself, however, some interesting complications are introduced by the value of the ground, the heavy traffic, etc.

It is impossible in this review to do more than give a general idea of the type of problems encountered; the practical value of the book lies in its complete presentation of the data at hand, and its faithful delineation of the lines of reasoning followed. The numerous and excellent plates and figures greatly clarify the text and enhance its interest. There seems little doubt that such geological work will come more and more into demand as its real value becomes recognized by engineers, and it is fortunate that one of the pioneers has been able in this report to sum up his experience and evaluate the various methods of attack. The author is to be congratulated, not only upon the success which later explorations have conferred upon his geological predictions, but upon the wisdom which he has displayed in presenting his report in so efficient and timely a manner.

G. S. Rogers

Daly, Reginald A. "The Nature of Volcanic Action," *Proc. Amer. Acad. Arts and Sci.*, XLVII (1911), 3, pp. 47–122.

In this highly suggestive paper Professor Daly has summed up and correlated a large part of his researches and speculations upon igneous rocks into a systematic hypothesis of volcanic action. The paper is an attempt to present a working hypothesis of vulcanism which will "co-

ordinate the accepted principles of vulcanology with each other and with the truths of plutonic geology"; and the group of conceptions advanced may be summarized in the name "substratum injection hypothesis," since the central thesis is that all vulcanism is the consequence of abyssal injection. The results arrived at in many of the papers which Professor Daly has published during the past few years are incorporated in the present treatise, and his recent studies in Hawaii are especially dwelt upon.

The theory postulates in the first place the existence of an acid shell in the earth's crust, overlain by the sedimentary pellicle, and underlain at a depth of about 40 kilometers by a basaltic substratum. The latter conception, although perhaps the most fundamental assumption in the whole theory, is advanced largely without argument, it being merely noted that most lava is of basaltic or andesitic composition. Taking the existence of this eruptible substratum for granted, then, the author proceeds to formulate the preliminary to vulcanism generally accepted as essential, viz., abyssal fissuring and magmatic injection. As the magma rises nearer the surface the great change in conditions will lead to certain immediate and direct consequences. In the first place, the basaltic magma will undergo an expansion of 1.5–6 per cent, energy being thus formed which may be available for opening fissures; secondly, the superheat existing in the magma will probably cause the assimilation of the wall rock, a point more fully discussed in a well-known former paper of the author's; and finally, the gases dissolved in the magma will tend to rise, supersaturating its upper levels, and finally separating as bubbles and collecting under the roof of the batholithic chamber. Emphasis is laid upon the necessity of defining the nature of these gases, since important functions are later to be ascribed to them. They are classified as magmatic and phreatic, the former class being made up of juvenile and resurgent (those derived from the country rock), and the latter of vadose and connate (those trapped in sediments).

The three phases of volcanic action are then fully considered. In fissure eruptions, which are always basaltic, the magma is highly superheated, as indicated by the low angle of slope and the great length of the flow. That no assimilation of acid country rock has taken place must be due to the fact that the feeding channel is always narrow. Expansion of the magma and the separation of its gases as indicated above are doubtless features in the effusion of such floods, although orogenic action is probably necessary to cause the initial abyssal fissuring. The second phase described is one less generally considered—eruption through local foundering. This is conceived as taking place when the magma is of

great size and is superheated sufficiently to allow of extensive assimilation of the overlying acid rock. It works its way up partly by piecemeal stoping of the roof, but a point is finally reached when a great part of the latter will cave in and founder in the fluid magma below. The assimilation of the surrounding rocks alters the composition of the latter, giving rise to a differentiation which results in the collecting of the acid phases at the top. The upper portions of the magma, which are usually liparitic, may overflow and produce a formation somewhat similar to a fissure eruption, but differing from it in being acid and in occurring in one thick flow rather than in several superposed sheets. The 600-meter sheet of rhyolite in Yellowstone Park is explained in this way. The fact that the geysers require more heat than such a flow can well supply is also accepted as a confirmatory indication that the rhyolite is not a true flow, but is merely the top layer of a great batholith which is basic in its lowest levels.

The paper, however, deals chiefly with the question of central eruptions, and the first problem presented is that of the opening and localization of the vent. If there be a pre-existent fissure it is doubtless susceptible of enlargement by the superheated lava; this may be accomplished by the solution and mechanical removal of the wall rock by the lava, or by the melting and explosive abrasion effects of the magmatic gas. If the latter become segregated and explosive, a diatreme, or tube surmounted by a funnel results, and this may also form in unfissured rock. In other cases the magmatic gases, highly heated and under great pressure, may collect in the hollows or cupolas of the roof of the batholithic chamber, thereby localizing and intensifying the stoping action of the magma. The latter may thus work the last few kilometers of its way to the surface unaided by a fissure.

A large part of the remainder of the paper is based upon an analysis of conditions in Kilauea. Mathematical calculations prove that an enormous amount of heat is lost at an open vent, and that the heat lost by radiation is over fifty times as much as that lost by conduction. Ordinary convection between the main feeding chamber and the vent is then proved inadequate to sustain heat in the latter. The conception of two-phase convection is then advanced: the magma rises continually because of its vesiculation, and, having discharged its gas at the surface of the lava lake, sinks again down the pipe to the main feeding chamber. This is the explanation of the currents in the Kilauea Lake and of the Old Faithful fountains which are thought to be located directly over the pipe, and to be due to the ever more rapid rise of the vesiculate magma as it nears the surface. Figures for the loss of density of the lava, after

a given amount of vesiculation, are adduced, and also for the velocity of solitary bubbles rising through a magma of given viscosity and at a given pressure; while the rate of rise of a mass of vesiculated lava in a non-vesiculate magma is estimated by the analogy of solid spheres moving under gravity in viscous liquids. These computations indicate that such a process is eminently possible, and it is regarded by the author as essential to the prolonged maintenance of activity. The action of the gases is further extended in the conception of the volcanic furnace. If the juvenile gases accumulate at the top of the magmatic chamber as indicated they will become concentrated in the actual volcanic pipe, and, according to the law of mass action, exothermic reactions on a large scale between the gases themselves are to be expected. Moreover, there may be other, and endothermic, compounds formed in the primitive earth, and the energy thus potentialized in the substratum will be liberated at these levels of greatly lessened pressure. Even before the magma reaches the surface such conditions will exist in the cupolas of the roof, and these highly heated gases, still under great pressure, will exercise a tremendous blowpiping action. The rôle of the gases in volcanic action is therefore a very important one.

The gas-fluxing hypothesis also explains the small size of observed volcanic pipes, since the slow passage of relatively small amounts of gas would not be expected to open a large vent. A very minute deformation would have a great effect on the rise of the gas, which would set all of the aforementioned processes in operation and reopen a dormant vent, so that the difficulty of explaining periodic vulcanism is lessened. Magmatic differentiation in central vents is to be largely explained upon principles which have been demonstrated in plutonic geology. Lava is however especially prone to differentiation, owing to the fact that it is kept fluid, but at a fairly low temperature, for a long time; that it has excellent opportunities for assimilating the wall rock; and that in each period of dormancy much of it passes through the stage of crystallization. Progress in magmatic differentiation decidedly favors explosiveness, which is due to the tension of the gases, so that it is only in fairly mature vents that this feature of volcanic activity is pronounced.

Direct offshoots of main abyssal injections have so far been considered. They form batholiths; and plutonic stocks and bosses are interpreted as cupolas in batholithic roofs. Sheets, dikes, and laccoliths are, however, distinctly satellitic, and soon lose thermal and hydrostatic communication with the main abyssal injection. It is only in the case of laccoliths that a mass of molten rock may be injected which will retain its heat for considerable periods; and such a mass may give rise

to subordinate vulcanism. Professor Daly considers Kilauea to be located upon a satellitic injection or laccolith. He formulates the characteristics of subordinate volcanoes as follows: brief activity, geologically speaking; small output of lava, a cluster grouping of the vents rather than an alignment, and the existence of traces of surface deformation due to the injection of the laccolith between the strata. Tertiary and Paleozoic examples are probably represented in Suabia and Scotland.

This theory of Professor Daly's is thus systematic and plausible, granting the existence of the basaltic substratum; and his practice of invoking the aid of physical formulas to support his ideas is highly commendable. To one who has not been closely following the work of Professor Daly along these lines, many of the somewhat novel views to which he casually refers in the present paper may be startling, but the more obvious objections to these at least have been disposed of in the author's previous articles. In a recent paper he estimates the amount of assimilation which a given mass of basalt can accomplish, and finds that about five mass-units of this rock will furnish the heat energy necessary for the solution of one mass-unit of granitic gneiss. A 5:1 mixture of rocks containing say 48 and 73 per cent of silica respectively would contain only about 52 per cent of that constituent, however, and it is evident that very extensive gravitative adjustment would be required to produce from this magma such a mass as the rhyolite flow at Yellowstone Park. The conception of Kilauea as a subordinate volcano is an interesting one; Professor Daly might perhaps have strengthened his argument by a calculation of the annual loss of heat of a laccolith of this size, and so have arrived at an estimate of the length of time that it could remain molten after injection. The fact that the whole theory is founded largely on the study of but one group of volcanoes might also be urged against it, but the paper nevertheless stands as a very interesting and suggestive discussion of those processes whose manifestations have long been the subject of speculation to the human race.

G. S. Rogers

Milch, L. "Ueber Plastizität der Mineralien und Gesteine," *Geolog. Rundschau*, Bd. II, Heft 3 (1911), 145–62.

Milch's paper presents the results of various investigators on the plasticity of minerals and rocks with a bibliography of the literature.

Perfect rigidity and plasticity are limiting conditions which no substances possess. A substance is perfectly rigid when it cannot be deformed by any amount of stress. It is perfectly plastic when it offers

no resistance to stress. Ordinarily, a substance is said to be plastic when it can be continuously deformed without rupture. Experiment shows that all substances are probably latently plastic depending on pressure, temperature, and time. Gypsum, stibnite, halite, calcite, ice, galena, cyanite, fluorite, apatite, anhydrite, bismuthunite, vivianite, lorandite, graphite, molybdenite, brucite, mica, and sylvite are found to be plastic at room temperature when subjected to pressure in one direction, as shown by the work of Brewster, Reusch, Bauer, Averbach, and Mügge. They are found to be more plastic in certain directions than in others. Mügge's experiments seem to indicate that plasticity in crystals is conditioned by "planes of translation," along which movement takes place when the crystal is deformed, and that crystals having "translation planes" are plastic under all physical conditions when adequate differential force is applied. About 77 crystal species have been tabulated by Vernadsky which show gliding planes, among them hornblende, topaz, dolomite, corundum, beryl, tourmaline, and epidote.

The conclusion seems justified that all substances, even those which have not been shown to be plastic by experiment, are plastic under the conditions which prevail in the deep parts of the earth, since the degree of plasticity increases with temperature and pressure. H. Tressa in 1864 showed that the plasticity of lead, aluminum, and ice was greatly increased under pressure. By means of pressure, W. Spring (1880) welded various metal powders and caused them to flow through an aperture. In 1902 and 1903 G. Tamman proved that flowage in these cases was due to internal friction and not to temporary melting.

After A. Heim had appealed to plasticity as the means by which mountain deformation is accomplished, confirmatory experiments seemed desirable. Pfaff's and Gümbel's experiments (1879 and 1880) were futile because they did not prevent fracture by supplying adequate pressure on all sides. In 1886 O. Mügge succeeded in getting plastic deformation of diopside, galena, and anhydrite by first imbedding them in lead or zinc and then subjecting them to pressures on all sides. In 1892, G. Kick imbedded test materials in molten alum, sulphur, and shellac inside a copper tube, and compressed them between the plates of a hydraulic press. He succeeded in getting plastic deformation of halite and marble. F. Rinne (1903), amplifying Kick's experiments, flattened calcite rhombohedra under a pressure of 1,200 Kg/qcm, but they partly broke into powder. Halite and sylvite, however, were deformed without fracture, loss of strength, or clearness. F. D. Adams (1910) continued Kick's experiments, and found that minerals were plastic in an inverse ratio to their hardness. Minerals less than 5 in

hardness were plastic. Fluorite was plastic. Diopside, hardness 5.5, developed polysynthetic twins. Apatite showed signs of plasticity. Orthoclase ruptured, but the particles were optically deformed. Quartz lacked plasticity, while marble was perfectly plastic. Granite suffered cataclastic deformation but became gneissose. In Kick's experiments the lateral resistance was insufficient and it was impossible to state how much pressure acted on the sample, since it was distributed over the metal tube, imbedding substance, and the sample itself. In order to overcome this trouble, F. D. Adams and C. G. Coker (1910) devised a thick tube of nickel steel, made of a steel block. The receiving tube was carefully bored out and polished and was slightly less in diameter than the cylinder of rock which was to be tested. The rock cylinder was inserted when the tube was hot. The compressing rod which fitted into the receiving tube was made of hard chrome-tungsten steel. The cartridge was weaker near the middle so as to prevent the material from flowing around the compressing rod. They succeeded in getting perfectly plastic deformation of Carrara marble and the strength tests showed an increase in strength with an increase in the deforming stress. The pressure exerted was equal to a depth of 41 miles of the earth's crust.

The following experiments illustrate the relation of temperature and pressure to plasticity. G. Tamman showed that for a series of metals an increase in temperature of 10 degrees caused a doubling of the rate of discharge through an aperture, all other conditions being equal. L. Milch showed that halite, melting point above 800°, is plastic at 200°C. Doelter observed that silicates pass through a transition stage of peculiar viscosity when passing from the crystalline to the molten state. Similarly, A. L. Day and E. T. Allen found that albite could be readily bent when in this state. "Protoklase" (see Rosenbusch, *Elemente der Gesteinslehre*, 65, 3d ed.) is explained by W. Salomon (1910) as the effect of the pressure of intrusion on magmas in this state. In 1901 Nicholson and Adams did not succeed in getting perfect plastic deformation of marble except at temperatures of 300°–400° C. In 1910, Adams and Coker succeeded in getting plastic deformation of marble at a lower pressure when it was heated than at ordinary temperatures.

The value of the time factor in plastic deformation is shown in the following experiments, which prove that extended plastication favors deformation. In 1910, F. D. Adams investigated the time factor by deforming a marble column one minute and finding on immediate testing that it retained 60 per cent of its crushing strength. It retained 65.7 per cent of its crushing strength when tested 100 days later and retained

on an average about 84.7 per cent when subjected for 30 days to a gradually increasing pressure. When left two years in the apparatus, one cylinder had even gained in strength. A marble cylinder deformed slowly for 64 days had about double the crushing strength of one equally deformed in 10 minutes.

However, deformation of rocks without fracture in nature is not believed by all to mean plastic deformation. Grubenmann, Becke, and Van Hise have emphasized the importance of mineral elongation normal to the pressure by means of solution on maximum pressure surfaces and redeposition on surfaces of minimum pressure through the agency of water. Opinions are also divided on the relation between rock deformation and the deformation of their constituent minerals. A. Heim (1908) believes that rock deformation and mineral deformation are distinct. A rock may be deformed without fracture as a whole, whereas its individual minerals may in part be fractured and others deformed as plastic objects. T. Lehmann (1889) regards deformation which is accomplished without rock fracture as a whole but by the fracture of individual minerals as "bruchlos," deformation without fracture. Weinschenk disbelieves in plastic deformation in general, but admits its possibility in slates and marbles, and claims they always present evidence of fracture. He asserts that in many cases schistosity was developed by magmas crystallizing under differential pressure. Steinmann (1907) is opposed to the latent plasticity view of A. Heim, but admits that thickening and thinning of rock strata has been important. C. Schmidt (1908) is not opposed to the view that plasticity is possible at sufficient depth but believes that Heim has not allowed for sufficient depth in his assumptions. C. R. Van Hise, Becke, U. Grubenmann, have emphasized the action of water as an agent in causing deformation without fracture, but do not deny that plastic deformation may be possible.

E. Steitmann

Pirsson, L. V., and Rice, W. N. "Geology of Tripyramid Mountain," *Am. Jour. Sci.*, 4th ser., XXXI (April, 1911), 269–91. Figs. 6.

Pirsson, L. V. "Petrography of Tripyramid Mountain," *Am. Jour. Sci.*, 4th ser., XXXI (May, 1911), 405–31. Fig. 1, and analyses.

The first paper describes the geology of Tripyramid Mountain, N.H., and discusses the probable origin of the mountain. In the second the several rock types entering into the composition of the Tripyramid

laccolithic intrusion are described in detail, both megascopically and microscopically. These include gabbro (hessose), norite (andose), monzonite (monsonase), and alkalic syenite (nordmarkose) in concentric zonal arrangement with which are associated as dike rocks quartz syenite-aplite (liparase) and lamprophyres (grano-andose and hornblende-grano-andose). The modes of the several rocks are determined and compared with the norm calculated from the chemical analyses.

The several types are considered to be differentiation products from an original monzonitic magma. Occurring as complementary final products of the differentiation are the two classes of dike rocks. In the case of the basic dikes it is shown that magmas of similar chemical composition may produce rocks of markedly different mineralogical composition—the essexite and camptonite dikes.

A brief general discussion follows on the broader application of the principles derived from the study of this peculiar aggregation of rocks, and the author concludes with a speculation concerning the origin of the alkalic magma.

A. W. STICKNEY

SOLLAS, W. J., and MCKAY, ALEXANDER. *The Rocks of Cape Colville Peninsula, Auckland, New Zealand.* Two vols. Wellington, 1905 and 1906. Pp. 289 and 215. Illustrated.

These two volumes constitute a report relating to the Hauraki goldfields of the Auckland Provincial District, and mainly to Cape Colville Peninsula. The preliminary part of the report, of over a hundred pages, by Alexander McKay, government geologist of New Zealand, gives a general introduction to the geology of the district. The remainder of the first volume and the greater part of the second is taken up with petrographic descriptions of some four hundred thin sections of rocks from the Colville Peninsula; the determinations and petrographical descriptions by Professor Sollas, and the illustrations and notes as to locality, formation, etc., by Mr. McKay. There are also described ninety-two thin sections from other parts of New Zealand, including the Cheviot Hills and the east shore of Palliser Bay, Wellington.

The volumes are profusely illustrated with hundreds of full-page halftones of thin sections, a most excellent though expensive method of assisting a reader to obtain an idea of the individual rock specimens. Unfortunately many of the halftones are not so sharp as they might be, but the work, on the whole, is the most elaborate catalogue of rock slides yet attempted.

ALBERT JOHANNSEN

THOMAS, HERBERT HENRY. "The Skomer Volcanic Series (Pembrokeshire)," *Quart. Jour. Geol. Soc.*, LXVII (1911), 175–212. Figs. 13; map 1, and analyses.

The extreme west coast of Pembrokeshire, England, with the immediately outlying islands to the west, of which Skomer Island is the largest, consist for the greater part of a succession of lava flows. The rocks furnish some unusual mineral associations; and two new rock types are developed and described. A descriptive bibliography relating to the geology of Skomer Island is given.

Stratigraphic evidence shows the volcanic rocks to be pre-Upper Llandovery, probably lower Arenig in age. The rocks are mainly a succession of thin subaerial lava flows of considerable lateral extent with which are associated a few doleritic sills representing a later intrusive stage. Interbedded with the volcanics are thin beds of conglomerates, quartzites, and red clays.

The petrography of eight distinct types of igneous rocks with several variants is described in detail, and their geographical distribution given. The rocks include soda-rhyolites and felsites, soda-trachytes, keratophyres, mugearites, olivine basalts, and olivine dolerites; and the two new types skomerite and marloesite.

These two new types are porphyritic rocks of rather basic composition, characterized by the association of a high proportion of albite with olivine and augite. The name skomerite is applied to a rock consisting of porphyritic laths of somewhat altered albite-oligoclase, subidiomorphic augite, and small idiomorphic crystals of olivine, in a groundmass of unoriented albite-oligoclase laths. Marloesite is described as containing glomeroporphyritic crystals of albite-oligoclase and altered olivine in a fine-grained groundmass of subidiomorphic augite, albite microlites, soda-bearing hornblende, and accessory iron minerals.

The more acid rocks of this series show interesting mineralogical variations from the generally recognized mineral associations. As the most notable peculiarity, these rocks contain soda-rich feldspar phenocrysts in intimate association with porphyritic crystals of olivine, hypersthene, and augite. The author recognizes the possibility of an original, more basic character of the rocks and a subsequent increase in soda-rich feldspar by albitization, but concludes, on good evidence, that the albite for the dominate part is original.

The rocks show an extrusive sequence from acid to basic and basic to acid, with a resulting frequent repetition of the same types of rocks.

A. W. STICKNEY